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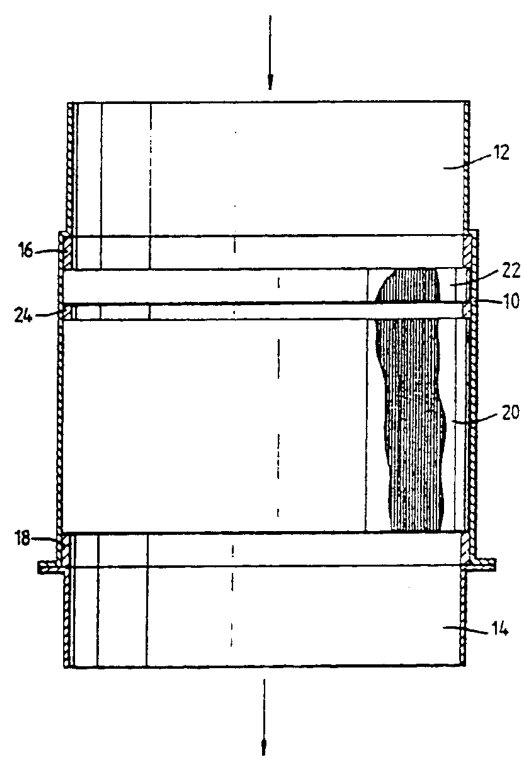
(54) Catalytic combustion.

(57) A catalytic combustion system, e.g. in a gas turbine, has a combustion catalyst supported by a honeycomb structure and an integral, or separate, catalyst-free honeycomb section upstream of the combustion catalyst acting as, or supporting, a flame trap.



Catalytic combustion

This invention relates to catalytic combustion wherein a gaseous or vaporised liquid fuel is combusted with an oxygen-containing gas, eg air, in the presence of a combustion catalyst. For convenience of description the oxygen-containing gas will be termed air, although it will be appreciated that oxygen itself, or oxygen-enriched or oxygen-depleted air can be employed.

Catalytic combustion may be used in a wide variety of applications and has numerous advantages, for example it tends to give combustion products having a lower nitrogen oxides content than a conventional flame combustion.

One application of catalytic combustion is in gas turbines wherein the fuel in the form of a compressed gas or vapourised liquid is mixed with a compressed oxygen-containing gas, normally air, and the mixture passed over a combustion catalyst. Catalytic combustion takes place giving a hot gas stream which is used to drive the turbine which in turn drives the compressor for the air and, if necessary, the fuel and also provides power for export, for example electricity produced in eg. an alternator driven by the turbine.

Another application is in industrial and domestic heaters, eg water heaters. For example catalytic combustion may be used for the burners of industrial fired heaters, for burners of domestic water boilers, eg of the fully-premixed burner type, and for pilot burners.

The catalysts for such catalytic combustion normally comprise a platinum group metal, eg platinum, palladium, rhodium, or materials such as vanadium pentoxide, or mixtures thereof supported on an inert support. The support is usually a refractory material, particularly alpha-alumina, and is conveniently in the form of a monolithic honeycomb structure, ie a single honeycomb unit, or assembly of polygonal honeycomb units packed side-by-side, each unit having a plurality of parallel passages extending therethrough in the direction of gas flow. Examples of suitable supports are described in EP-A-206535, and EP-A-226306, and a suitable method for their manufacture is described in EP-A-134138.

During operation, the honeycomb becomes relatively hot. At least at start-up of the combustion the fuel/air mixture is fed to the honeycomb at an elevated temperature and rapid combustion occurs upon contact with the combustion catalyst. The preheating of the fuel/air mixture may be effected in a variety of ways, eg by the heat generated during compression or by the addition of a heated ballast gas, eg steam. However the temperature of the fuel/air mixture should be below the autoignition temperature. After start-up the inlet temperature of the fuel/air mixture may be reduced but the catalyst remains at elevated temperature. During normal operation the fuel/air mixture is supplied at such a rate that the mixture enters the combustion catalyst before it has been heated to above the autoignition temperature by the heat radiated back from the combustion catalyst honeycomb. However there is a risk that, during some stages of operation, particularly when the flow rate is reduced, eg. during part load operation and/or at shut down, the incoming fuel/air mixture would be heated to above the autoignition temperature by the aforesaid back-radiated heat. This would lead to autoignition of the fuel/air mixture and there may be a risk that the resultant flame would travel back towards the fuel and/or air inlet and cause damage to the containing vessel. There is also a possibility that, during a rapid shut-down of the system, the catalyst temperature remains high while the inlet gas velocity falls below the flame velocity (which is typically up to 6m/s but may be as high as 10 m/s in exceptional cases) and a flame front can accelerate away from the hot catalyst giving a detonation or unstable combustion conditions upstream of the catalyst leading to thermal stressing of the catalyst.

The present invention seeks to overcome these problems, and is of particular use in applications, such as gas turbines, or domestic water heaters, where it is desired that there may be a frequent stopping and starting of the combustion.

In the present invention a flame trap is provided upstream of the combustion catalyst, so that in the event of autoignition, a flame cannot travel back toward the fuel/air inlet.

Accordingly the present invention provides, in a catalytic combustion system wherein combustion of a fuel/air mixture is effected by passage of the fuel/air mixture over a combustion catalyst supported on a monolithic honeycomb structure, the improvement comprising the provision of a flame trap upstream of said combustion catalyst, said flame trap comprising, or being supported on its downstream side by, a combustion catalyst-free honeycomb section.

The combustion catalyst-free section may itself be the flame trap or may be a support for a conventional gauze flame trap. The combustion catalyst-free section will be cooler than the catalyst-containing honeycomb and so autoignition of the fuel/air mixture upstream of the combustion catalyst-free honeycomb as a result of heating by radiant heat from the combustion catalyst will be less liable to occur.

The through passages in the honeycomb gen-

erally have a hydraulic diameter of less than 5 mm, particularly less than 2.5 mm, and generally above 0.1 mm. By the term hydraulic diameter we mean four times the cross sectional area of the passage divided by the perimeter of the passage cross section. [In the case of passages of circular cross section, the hydraulic diameter is thus the diameter of the passage cross section, while for passages having a cross section in the form of a regular polygon, the hydraulic diameter is the diameter of the inscribed circle]. The cross sectional configuration of the passages is preferably rectangular, particularly square, or triangular, particularly isosceles, eg. equilateral or right angled, eg, as a result of dividing a square diagonally. The honeycomb preferably has an open area of at least 30%, particularly 40-90%, and, in the case of polygonal cross section passages, the walls between adjacent passages preferably have a thickness of 0.05 to 1 mm. There are preferably 10-100, particularly 15-50, passages per cm^2 of the unit cross sectional area.

The catalyst-free honeycomb section may in one form of the invention be integral with the catalyst-bearing honeycomb, for example as a result of applying a coating of the combustion catalyst only to the downstream portion of a honeycomb. This form of construction is simple but has the disadvantage that there is a risk that, because of the difference in temperature that is liable to occur between the uncoated region and the catalyst-bearing region, the uncoated region is liable to separate from the catalyst-bearing region as a result of cracking due to thermal shock. This risk can be minimised by restricting the length of the uncoated region to no more than about 100, preferably no more than about 50, times the hydraulic diameter of the passages. The uncoated region should have a length of at least one, and preferably at least five, times the passage hydraulic diameter, particularly if the uncoated region is itself to act as the flame trap rather than simply supporting a conventional flame trap.

Alternatively a separate catalyst-free honeycomb unit, or assembly of units, may be used upstream of the combustion catalyst-bearing honeycomb, again as the flame trap itself or as a support for a wire gauze flame trap. In this case the aforementioned disadvantage of the risk of separation as a result of thermal shock causing cracking of course will not occur. In this embodiment it will be appreciated that the passage dimensions of the catalyst-free honeycomb may differ from those of the combustion catalyst-bearing honeycomb. However it is preferred that the dimensions are within the aforementioned ranges.

Where the combustion catalyst-free honeycomb is itself to act as a flame trap, the hydraulic diameter of the passages is preferably within the range 0.5 to 2.5 mm and the length of the passages is typically up to 100 mm, preferably less than 50 mm.

Whether or not the catalyst-free honeycomb is itself to act as the flame trap, the minimum length is dictated by the need to provide sufficient strength to be self-supporting. The length necessary to be self supporting will normally exceed the length that is necessary for the catalyst-free honeycomb to be effective as a flame trap and will normally be at least one, particularly at least five, times the passage hydraulic diameter.

Where the honeycomb is used to support a conventional flame trap, it will be appreciated that the passage hydraulic diameter can be larger than would be effective for a flame trap. By the use of larger hydraulic diameter passages, the pressure drop that occurs as the fuel/air mixture passes therethrough can be reduced. The use of a catalyst-free honeycomb as a support for a conventional flame trap overcomes the difficulties associated with supporting a conventional flame trap in the extremes of temperature and gas velocity encountered in service.

The invention is illustrated by reference to the accompanying drawing which is a diagrammatic section of the combustion zone of a gas turbine.

In the drawing there is shown a combustion zone comprising a cylindrical casing 10 provided at one end with an inlet region 12 to which compressed air is supplied and into which fuel can be injected and vaporised (if not already gaseous), eg by conventional means not shown. The casing 10 is provided at its other end with an outlet region 14 for hot combusted gas to be fed to the turbine section. Locating rings 16, 18, typically of alpha-alumina, are provided at each end of the cylindrical casing 10. Located between the rings 16, 18 are two honeycomb units 20, 22 with a spacer ring 24 of alpha-alumina, or an insulating material, therebetween. Ceramic fibre packing (not shown) may be provided to accomodate relative thermal expansion between rings 16, 18, 24 and the casing 10, and between the casing 10 and honeycomb units 20, 22.

Honeycomb 20 is typically made from an alpha-alumina or other inert ceramic material having a low coefficient of thermal expansion composition by extrusion followed by firing and bears a combustion catalyst, typically 0.05 to 10% by weight of the honeycomb of platinum or vanadium pentoxide applied by impregnation, precipitation or dipping. Honeycomb 22 is of similar construction to honeycomb 20 but is shorter and has no combustion catalyst and acts as a flame trap to prevent autoignition of the fuel/air mixture upstream of honeycomb 22.

In a typical example, honeycombs 20 and 22

have a diameter of 450 mm and 33 through passages per cm^2 of unit cross section. The passages are of equilateral triangular cross section of hydraulic diameter about 1.2 mm with a wall thickness between adjacent passages of about 0.25 mm. The open area of the honeycomb is about 66%. The catalyst-bearing honeycomb 20 has a length of 150 mm while the catalyst-free honeycomb 22 has a length of only 25 mm. The distance between honeycomb units 20 and 22 is 5 mm.

Claims

1. A catalytic combustion system wherein combustion of a fuel/air mixture is effected by passage of the fuel/air mixture over a combustion catalyst supported on a monolithic honeycomb structure, characterised by the provision of a flame trap upstream of said combustion catalyst, said flame trap comprising, or being supported on its downstream side by, a combustion catalyst-free honeycomb section.

2. A catalytic combustion system according to claim 1 wherein the honeycomb support structure has a coating of the combustion catalyst, and the catalyst-free honeycomb section is an uncoated portion of said honeycomb support structure and has a length of not more than 100 times the hydraulic diameter of the passages extending through the honeycomb.

3. A catalytic combustion system according to claim 1 wherein the catalyst-free honeycomb section is separate from the honeycomb structure supporting the combustion catalyst.

4. A catalytic combustion system according to any one of claims 1 to 3 wherein the catalyst-free honeycomb section has a length of at least 5 times the hydraulic diameter of the passages extending through the honeycomb.

5. A catalytic combustion system according to any one of claims 1 to 4 wherein the passages extending through the honeycomb section, or sections, have a hydraulic diameter of less than 5 mm.

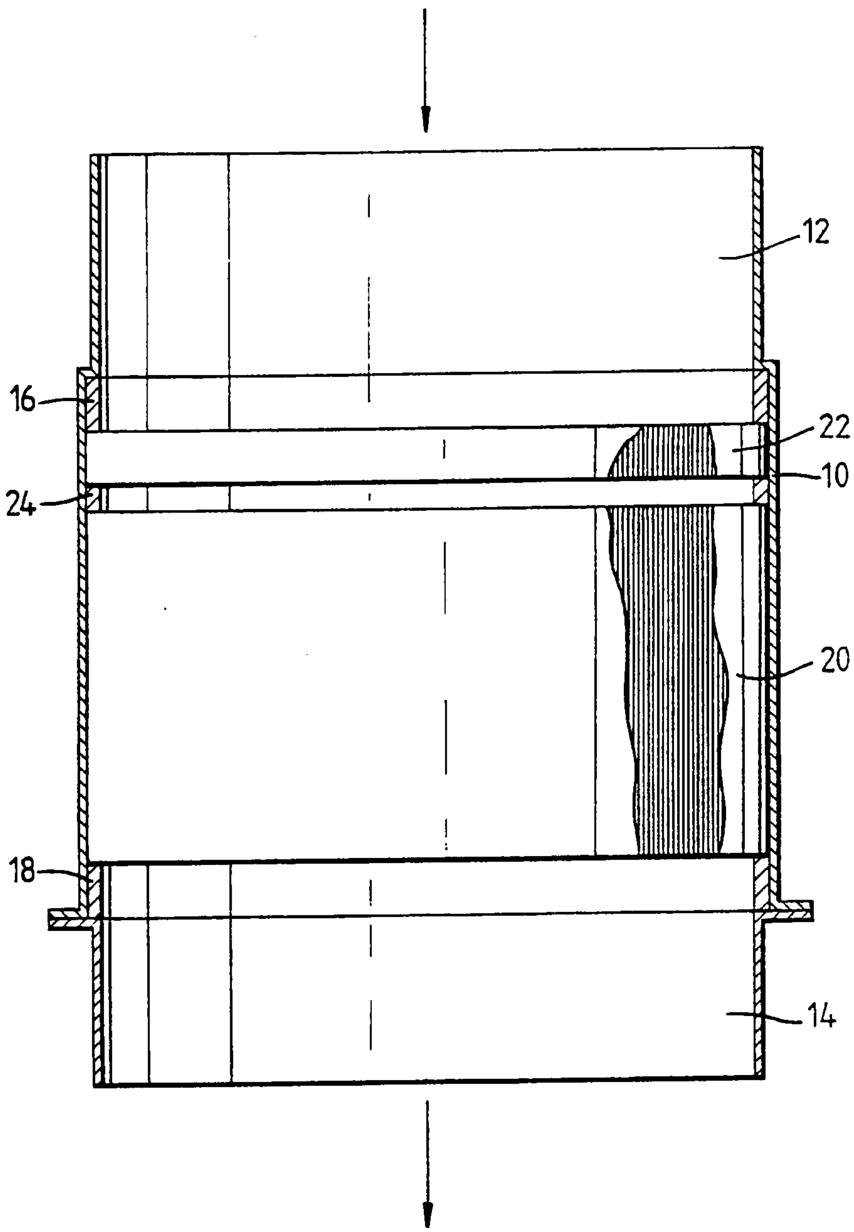
6. A catalytic combustion system according to any one of claims 1 to 5 wherein the cross section of the honeycomb section, or sections, has an open area of at least 30%.

7. A catalytic combustion system according to any one of claims 1 to 6 wherein the honeycomb section, or sections, have 10 to 100 passages per cm^2 of the honeycomb cross section.

8. A catalytic combustion system according to any one of claims 1 to 7 wherein the catalyst-free honeycomb section itself forms the flame trap and the hydraulic diameter of the passages of the catalyst-free honeycomb section is within the range 0.5 to 2.5 mm and the length of the passages is less than 100 mm.

9. A gas turbine incorporating a catalytic combustion system according to any one of claims 1 to 8.

10. A domestic water boiler incorporating a catalytic combustion system according to any one of claims 1 to 8.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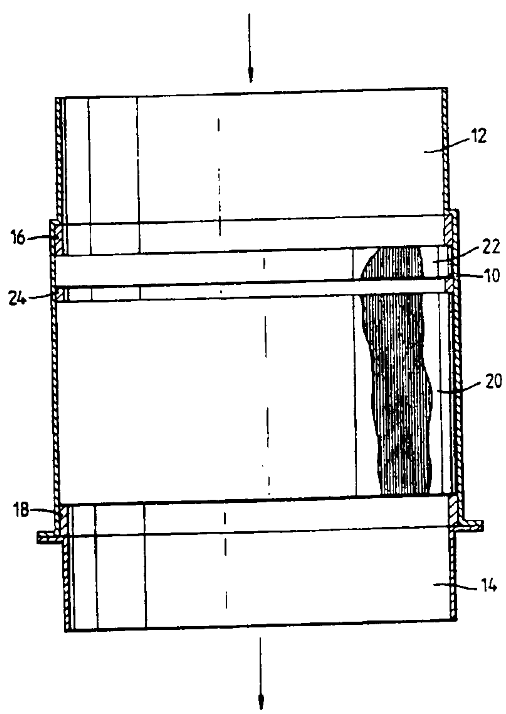

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EUROPEAN SEARCH REPORT

Application Number

EP 89 30 6359

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	PATENT ABSTRACTS OF JAPAN, vol. 7, no. 165 (M-230)[1310], 20th July 1983; & JP-A-58 72 808 (MATSUSHITA DENKI SANGYO K.K.) 30-04-1983	1	F 23 D 14/82 F 23 D 14/18
A	IDEM	8	
X	PATENT ABSTRACTS OF JAPAN, vol. 7, no. 157 (M-227)[1302], 9th July 1983; & JP-A-58 62 410 (MATSUSHITA DENKI SANGYO K.K.) 13-04-1983	1	
A	IDEM	8	
A	DE-A-3 332 572 (INSUMMA) * Page 5, line 21 - page 6, line 21; page 11, line 29 - page 12, line 19; page 14, lines 14-26; figure *	1,3,10	
A	EP-A-0 144 094 (FURUYA) * Page 1, lines 1-9; page 24, line 19 - page 25, line 4; page 46, lines 2-7; figures 31,32 *	8,9	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN, vol. 9, no. 297 (M-432)[2020], 25th November 1985; & JP-A-60 134 117 (ENU KOA K.K.) 17-07-1985		F 23 D F 23 C F 01 N F 23 R
A	DE-A-3 613 745 (STEULER)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13-08-1990	PHOA Y.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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